SECTION 3 - EQUIVALENT PROCEDURES FOR PROPELLER DRIVEN AEROPLANES OVER 9000 kg

The following procedures have been used as equivalent in stringency to Chapter 3 and Chapter 5, Annex 16, Volume 1 for propeller driven aeroplanes with maximum certificated take-off mass exceeding 9000 kg.

3.1 FLIGHT TEST PROCEDURES

3.1.1 Flight path intercept procedures

Flight path intercept procedures, as described in 2.1.1 of this manual, have been used to meet the demonstration requirements of noise certification in lieu of full take-offs and/or landings.

3.1.2 Generalised flight test procedures

Generalised flight test procedures (other than normal noise demonstration take-offs and approaches) have been used to meet two equivalency objectives:

a) *to acquire noise data over a range of engine power settings at one or more heights*: this information permits the development of generalised noise characteristics necessary for certification of a "family" of similar aeroplanes. The procedures used are similar to those described in 2.1.2.1 with the exception that the NPD plots employ engine noise performance parameters (μ) of M_H (propeller helical tip Mach number) and SHP/d_{amb} (shaft horse power) (see Fig 3), where δ_{amb} is defined in 2.1.2.1.3.

   In order to ensure that propeller inflow angles are similar throughout the development of the noise-sensitivity data as the aeroplane mass changes, the airspeed of the aeroplane used in the flight tests for developing the lateral and flyover data shall be V_2 + 19 km/h (V_2 + 10 kt) to within ±6 km/h or ±3 kt appropriate for the mass of the aeroplane during the test.

   For the development of the NPD data for the approach case the speed and approach angle constraints imposed by 5.6.3(b), 5.7.5, 3.6.3 and 3.7.5 of Chapters 5 and 3 of Annex 16, Volume 1, cannot be satisfied over the typical range of power needed. For the approach case the speed shall be maintained at 1.3 V_S + 19 km/h (1.3 V_S + 10 kt) to within ±6 km/h or ±3 kt and flyover height over the microphone maintained at 400 ft ±100 ft. However the approach angle at the test power shall be that which results from the aeroplane conditions, ie. mass, configuration, speed and power; and

b) *Noise level changes* determined by comparisons of fly-over noise test data for different developments of an aeroplane type, for example, a change in propeller type, have been used to establish certification noise levels of a newly derived version as described in 2.1.2.2.

3.1.3 Determination of the lateral noise certification level

Determination of the lateral noise certification level employing an alternative procedure using two microphone stations located symmetrically on either side of the take-off flight path similar to that as described in 2.1.3 has been approved. However, when this procedure is used, matching data from both lateral microphones for each fly-by must be used for the lateral noise determination; cases where data from only one microphone is available for a given fly-by must be omitted from the determination. The following paragraphs describe the procedures for propeller-driven heavy aeroplanes.

3.1.3.1 The lateral Effective Perceived Noise Level from propeller driven aeroplanes when plotted against height opposite the measuring sites can exhibit distinct asymmetry. The maximum EPNL on one side of the aeroplane is often at a different height and noise level from that measured on the other side.

3.1.3.2 In order to determine the average maximum lateral EPNL, ie. the certification sideline noise level, it is therefore necessary to undertake a number of flights over a range of heights to define the noise versus height characteristics for each side of the aeroplane. A typical height range would cover between 30 m (100 ft) and 550 m (1,800 ft) above a track at right angles to and midway along the line joining the two microphone stations. The inter-section of the track with this line is defined as the reference point.

3.1.3.3 Since experience has shown the maximum lateral noise level may often be near the lower end of this range a minimum of six good sets of data, measured simultaneously from both sides of the flight track, should be obtained for a range of aeroplane heights as low as possible. In this case take-offs may be necessary, however care should be taken to ensure that the airspeed is stabilised to at least V_2 + 19 km/h (V_2 + 10 kt) over the 10 dB-down time period.

3.1.3.4 The aeroplane climbs over the reference point using take-off power, speeds and configuration as described in 3.6.2.1 c) and d) of Chapter 3 or 5.6.2.1 c) and d) of Chapter 5 of Annex 16, Volume 1.

3.1.3.5 The lateral certification noise level is obtained by finding the peak of the curve of noise level (EPNL) corrected to reference day atmospheric absorption values, plotted against aeroplane height above the reference point (see Fig. 9). This curve is described as a least squares curve fit through the data points defined by the median values of each pair of matched data measured on each side of the track (i.e. the average of the two microphone measurements for a given aeroplane height).

3.1.3.6 To ensure that the requirements of 5.4.2 of Appendix 2 or 5.5.2 of Appendix 1 of Annex 16, Volume 1, are met the 90 per cent confidence limits should be determined in accordance with paragraph 2.2 of Appendix 1 of this manual.

3.1.4 **Measurements at non-reference points**

3.1.4.1 In some instances test measurement points may differ from the reference measurement points specified in Chapters 3 and 5 of Annex 16, Volume 1. Under these circumstances an applicant may request approval of data that have been adjusted from actual measurements to the reference conditions for reasons described in 2.1.5.2 a), b) and c).

3.1.4.2 Noise measurements collected closer to the test aeroplane than at the certification reference points are particularly useful for correcting propeller noise data as they are dominated by low frequency noise. The spectra rolls off rapidly at higher frequencies and is often lost in the background noise at frequencies above 5000 Hz. Appendix 3 describes an alternative procedure.

3.1.4.3 Non-reference measurement points may be used provided that measured data are adjusted to reference conditions in accordance with the requirements of section 9 of Appendix 1 or 2 of Annex 16, Volume 1 and the magnitude of the adjustments does not exceed the limits in paragraphs 3.7.6 of Chapter 3 and 5.7.6 of Chapter 5 of the Annex.

3.1.5 **Reference approach speed**

The reference approach speed is currently contained in 3.6.3.1(b) of Chapter 3 of Annex 16, Volume 1 as 1.3 V_S + 19 km/h (1.3 V_S + 10 kt). There is a change being made to the definition of stall speed, for airworthiness reasons, to alter the current minimum speed V_S definition to a stall speed during a 1-g manoeuvre (ie. a flight load factor of unity) V_{S1g}. In terms of the new definition the approach reference speed becomes 1.23 V_{S1g} + 19 km/h, (1.23 V_{S1g} + 10 kt) which can be taken as equivalent to the reference speed contained in Chapter 3.

3.2 ANALYTICAL PROCEDURES

3.2.1 Analytical equivalent procedures rely upon available noise and performance data for the aeroplane type. Generalised relationships between noise levels, propeller helical tip Mach number, and shaft horsepower and correction procedures for speed and height changes in accordance with the methods of Appendix 2 of Annex 16, Volume 1, are combined with certificated aeroplane performance data to determine noise level changes resulting from type design changes. The noise level changes are then added to or subtracted from the noise certification levels demonstrated by flight test measurements for the flight datum aeroplane.

3.2.2 Certifications using analytical procedures have been approved for type design changes that result in predictable noise level differences including the following:

a) an increase or decrease in maximum take-off and/or landing mass of the aeroplane from the originally certificated mass;

b) power increase or decrease for engines that are acoustically similar and fitted with propellers of the same type;

c) aeroplane, engine and nacelle configuration changes, usually minor in nature, including derivative aeroplane models with changes in fuselage length and flap configuration. However, care is needed to ensure that existing noise sources are not modified by these changes, e.g. by changing the flow field into the propellers; and

d) minor airframe design changes that could indirectly affect noise levels because of an impact on aeroplane performance (increased drag for example). Changes in aeroplane performance characteristics derived from aerodynamic analysis or testing have been used to demonstrate how these changes affect the aeroplane flight path and hence the demonstrated noise levels of the aeroplane.

3.3 GROUND STATIC TESTING PROCEDURES

3.3.1 **General**

Unlike the case of a turbojet or turbo fan powerplant, static tests involving changes to the propeller are not applicable to determining noise level changes in the development of a propeller driven aeroplane/powerplant family. This is caused by changes in the aero-acoustic operating conditions of the propeller when run statically compared with conditions existing during flight. The propeller noise levels measured during a static test can include significant contributions from noise source components not normally important in flight. However, limited static tests on engines with propellers, which are used as engine loading devices can be utilised to determine small noise changes, as described below.

3.3.2 **Guidance on the test site characteristics**

Guidance on the test site characteristics data acquisition and analysis systems, microphone locations, acoustical calibration and measurement procedures for static testing is provided in SAE ARP 1846 and is equally valid in these respects for propeller power plants.

3.3.3 **Static tests of the gas generator**

3.3.3.1 Static tests of the gas generator can be used to identify noise changes resulting from changes to the design of the gas generators or the internal structure of the engine in the frequency ranges where there is a contribution to the aeroplane EPNL, or where that part of the spectrum is clearly dominated by the gas generator or ancillary equipment under circumstances where the propeller and its aerodynamic performance remains unchanged.

3.3.3.2 Such circumstances include, for example, changes to the compressor, turbine or combustor of the powerplant. The effect of such changes should be conducted under the same test, measurement, data reduction and extrapolation procedures as described in paragraph 2.3 for turbojet and turbofan engines. The noise from any propeller or other power extraction device used in static tests should be eliminated or removed analytically. For the purposes of aeroplane EPNL calculation, the measured flight datum aeroplane propeller contributions should be included in the computation process.